IN THE SPECIFICATION

Please amend the portions of the Specification identified below to read as indicated herein.

At page 1, line 3, please insert the following heading and related narrative:

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of International Application No. PCT/EP02/09107, filed August 14, 2002. The PCT/EP02/09107 application claims priority of German Patent Application No. 101 39 188.9, filed August 16, 2001.

At page 1, line 3, after the newly inserted CROSS-REFERENCE TO RELATED APPLICATIONS and related narrative, as provided above, please insert the following two headings:

BACKGROUND OF THE INVENTION

1. Field of the Invention

Paragraph starting at page 1, line 4:

The invention relates to a substrate material for X-ray optical components, comprising a glass ceramic material with a thermal expansion $|\alpha| \leq 5 \times 10^{-6} K^{-1}$ in a predetermined temperature range of~~$\leq 5 \times 10^{-6} K^{-1}$~~, a method for producing such a substrate material~~as well as the~~, and a use of such a substrate material.

At page 1, line 8, please insert the following heading:

2. Description of the Related Art

Paragraph starting at page 1, line 9:

~~x-ray~~ X-ray optical components are especially of particular interest in the field of X-ray lithography. This applies in particular to lithography with soft x-rays, i.e.,~~, the so-called EUV lithographies~~ EUV lithography in the wavelength region of 10 to 30 nm. Mirrors with the highest possible reflectivity in the X-ray region are used as optical components in the field of X-rays. Such X-ray mirrors can be operated close to perpendicular incidence or in grazing incidence, namely as so-called normal or grazing incidence mirrors.

Paragraph starting at page 1, line 17:

X-ray mirrors ~~comprising~~ comprise a substrate and, based thereon, a multilayer system~~, namely so-called~~. The multilayers are also known as "Distributed Bragg Reflectors" (DBRs).~~, which will be referred to hereinafter as multilayers. They~~ The multilayers allow the realization of mirrors with high reflectivity in the X-ray region in the case of non-grazing incidence, i.e. in the normal incidence operation. A grazing incidence mirror has a simpler structure than a normal incidence mirror because the grazing incidence mirror has fewer of the multilayers.

Paragraph starting at page 1, line 23:

X-ray mirrors ~~which~~ that are operated close to perpendicular incidence (normal incidence) are ~~chosen~~ preferred over mirrors ~~with glancing~~ that are operated with grazing incidence ~~(grazing incidence) which are covered with simpler layers~~ in cases where high imaging quality by low

aberrations is required, ~~i.e. preferably~~ e.g., in imaging systems such as projection lens systems for EUV lithography systems.

Paragraph starting at page 2, line 1:

Reference is hereby made to DE 199 23 609 A1 and ~~the~~ US Application Serial No. 09/322,813, as filed with the US Patent Office on 28 May 1999 under the title "~~reduction~~ Reduction objective for extreme ultraviolet lithography", now US Patent No. 6, 244,717, concerning projection lens systems for EUV lithography and related X-ray optical components, the scope of disclosure of which is hereby fully ~~included in~~ incorporated into the present application.

Paragraph starting at page 2, line 8:

Multilayer systems based on the substrate can be layer systems comprising layer pairs of Mo/Si, Mo/Be, or MoRu/Be ~~layer stacks with~~, and having 40 to 100 such layer pairs. Such systems ~~lead in the EUV range $\lambda_R = 10$ to 30 nm to top-notch~~ provide reflectivity in the region of 70 to 80% in the EUV range $\lambda_R = 10$ to 30 nm. Depending on the wavelength of the light to be reflected, layer systems of other materials can be used.

Paragraph starting at page 2, line 14:

The high reflectivity of the layer stack is achieved by phase-adjusted superposition and constructive interference of the partial wave fronts reflected on the individual layers. The layer thicknesses must be ~~checked typically in the region of less than~~ controlled to be within about 0.1 nm of a desired thickness.

Paragraph starting at page 2, line 19:

The necessary preconditions for the achievement of high reflectivity are sufficiently low layer and substrate roughness in the high spatial frequency roughness (HSFR) range. Depending on the approach, this spatial frequency range leads to loss of light by scattering outside of the image field of the lens system or by disturbance of the microscopically phase-correct superposition of the partial wave trains. The relevant spatial frequency range is downwardly ~~delimited~~ limited by the criterion of scattering outside of the image field and depending on the application it is typically at EUV wavelengths in the region of some µm. Generally, no limit is specified towards high spatial frequencies. A useful limit value lies in the range of half the wavelength of the incident light, because higher spatial frequencies are no longer seen by the incident photons. HSFR is usually measured with atomic force microscopes ~~(SFM)~~ (AFM) which have the required lateral resolution.

Paragraph starting at page 3, line 2, and extending to line 9:

Concerning the definition of HSFR, MSFR and fine surface figure error ~~which is used in the following application~~, as used herein, reference is hereby made to:

U. Dinger, F. Eisert, H. Lasser, M. Mayer, A. Seifert, G. Seitz, S. Stacklies, F. J. Stiegel, M. Weiser, "Mirror Substrates for EUV-lithography; progress in metrology and optical fabrication technology", Proc. SPIE Vol. 4146, 2000, the scope of disclosure of which is hereby fully ~~included in~~ incorporated into the present application.

Paragraph starting at page 3, line 17:

Other X-ray optical components may require a structure ~~which~~ that is characterized by high reflectivity and low thermal expansion. Examples are a reticle mask for an EUV projection illumination system, a mirror with raster elements, a so-called optical integrator or a collector mirror of an EUV illumination system. Reference is hereby made to DE 199 03 807 A1 and ~~the~~

US Application Serial No. 09/305,017, as filed with the US Patent Office on 4 May 1999 under the title "Illumination system particularly for EUV lithography", now US Patent No. 6,198,793, the scope of disclosure of which is hereby fully ~~included in~~ incorporated into the present application.

Paragraph starting at page 4, line 11:

Surface figure error and also the long-wave shares in MSFR (mm waves) can be brought to specification with beam processing methods, i.e. the IBF (ion beam figuring). The advantage of this method is that ~~their~~ tools used in the method can sit closely to the working surface ~~so as to come to a snug fit especially~~, and so the tools can fit snugly on the typically aspheric surfaces. These beam processing methods are based on sputtering processing. The global and local sputtering rates depend on the physical and chemical bonding conditions in the solid body to be processed.

Paragraph starting at page 4, line 19:

Whereas in single-crystalline silicon the additional energy ~~introduction~~ introduced by the incident ions leads to a surface reorientation with the result of improved roughness, a slight deterioration of HSRF is observed in amorphous glass from approx. 0.06 to 0.15 nm rms. In semi-crystalline glass ceramic material ~~like~~ such as ZERODUR® for example, with a crystalline size of greater than 50 nm, there was a serious deterioration from 0.1 to 0.4 nm rms.

Paragraph starting at page 4, line 27:

Glass ceramic materials with a crystallite size of high quartz mixed crystals ≥ 80 nm and a mean coefficient of thermal expansion ~~$a_{20°C-700°C}$~~ $\alpha_{20°C-700°C} < 0.5 \cdot 10^{-6}/K$ are known from DE 199 07 038 A1.

Paragraph starting at page 4, line 31:

Heat-resistant ceramic materials with a mean surface roughness ≤ 0.03 μm are shown by JP-A-04-367538. ~~It~~ JP-A-04-367538 does not ~~make any statements~~ provide any disclosure concerning the mean thermal expansion. Furthermore, ~~it~~ JP-A-04-367538 makes no statements as to the spatial frequency range in which these roughness values are achieved.

Paragraph starting at page 5, line 5:

Although the single-crystalline silicon is a suitable carrier under the aspect of the roughness requirements ~~placed on~~ that are demanded for the substrate material, ~~it comes with~~ single-crystalline silicon has a mechanical anisotropy however and only allows for small mirror sizes due to its property as single crystal. Although the disadvantage of a coefficient of thermal expansion α which is higher than that of glasses can be compensated partly by a considerably higher thermal conductivity and suitable cooling, it still requires a high amount of technical effort. Silicon as a substrate is currently only considered in the case of very high thermal loads such as in illumination systems.

Paragraph starting at page 5, line 15:

Although the thermal expansion and the roughness in the HSFR range are unproblematic when using amorphous glasses with low thermal expansion such as glasses as described in US 2,326,059, sufficient surface figure error and MSFR values cannot be reached because the lamellae-like striated structure or Schlieren-structure of amorphous glass with negligibly low thermal expansion has a disadvantageous effect in these frequency ranges. As a result, these layers of a thickness of approx. 0.1 mm on moderately curved mirror surfaces lead to non-correctable surface modulations in the mm range with amplitudes of a number of nanometers far

outside the values required for ~~EUVL~~ EUV lithography. This effect is also observed in ion-beam-based production processes.

At page 6, line 6, please insert the following heading:

SUMMARY OF THE INVENTION

Paragraph starting at page 6, line 7:

The object of the invention is achieved by a glass ceramic material as a substrate material for X-ray optical components with an amorphous and a crystalline glass share. The glass ceramic material has a low coefficient of thermal expansion, the size of the crystallites, also known as microcrystallites, is $< 4\lambda_R$, preferably $< 2\lambda_R$, especially preferably $< \lambda_R$, even more preferably $<$ ~~$2/3\lambda_R$~~ $2\lambda_R/3$, especially $< \lambda_R/2$, with λ_R designating the mean wavelength of the incident X-rays. The substrate material in accordance with the invention still has ~~sufficient~~ sufficiently low roughness in the HSFR range after surface treatment, especially after an ion beam figuring (IBF) process.

At page 6, line 16, please insert the following heading:

DESCRIPTION OF THE INVENTION

Paragraph starting at page 7, line 21:

They are further characterized by low roughness in the middle spatial frequency roughness ~~range~~ (MSFR) range. These spatial wavelengths lead to light scatter within the image field (flare) and thus to losses in contrast for the imaging lens systems. The errors in the MSFR region can be

estimated from formulas for TIS (total integrated scatter). With the invention it is possible to achieve defects in the region of 0.1 to 0.2 nm in ~~EUVL~~ EUV lithography applications.

Paragraph starting at page 8, line 5:

The roughness of the X-ray optical components in the high spatial frequency roughness (HSFR) range is < $\lambda_R/30$ rms, preferably < $\lambda_R/50$ rms, especially preferably < $\lambda_R/100$ rms. At the same time the defect in the low spatial frequency range (which is the fine surface figure error range) is in the region of $\lambda_R/50$ - $\lambda_R/100$ rms and the roughness in the middle spatial frequency ~~region~~ roughness (MSFR) region lies simultaneously in the region $\lambda_R/50$ - $\lambda_R/100$ rms. At an EUV wavelength of 13 nm this corresponds to a roughness of 0.26 nm to 0.13 nm. The advantage of the substrate material in accordance with the invention is therefore that the roughness values lie in the different frequency ranges (fine surface figure error, MSFR, HSFR) in the region of 0.26 nm to 0.13 nm for EUV wavelengths.

Paragraph starting at page 8, line 30:

In addition to the glass ceramic material, the invention also provides a method for producing an X-ray optical component for X-rays of wavelength λ_R, comprising the following steps: The surface of the X-ray optical component is superpolished until a high spatial frequency roughness (HSFR) < $\lambda_R/50$ rms, preferably $\lambda_R/100$ rms, is achieved. Thereafter the surface is further processed with a beam processing method until the defect in the low spatial frequency region is in the range of $\lambda_R/50$ - $\lambda_R/100$ rms and the defect in the middle spatial frequency ~~region~~ roughness (MSFR) region is in the range of $\lambda_R/50$ - $\lambda_R/100$ rms. The materials in accordance with the invention are characterized in that HSFR does not deteriorate substantially after beam processing, but that even after completion of this processing step an HSFR < $\lambda_R/50$ rms, preferably < $\lambda_R/100$ rms, is achieved.

Paragraph starting at page 10, line 4:

In the glass ceramic substrate materials, microcrystallites with negative thermal expansion are embedded in amorphous material with positive thermal expansion. During ~~the~~ crystallization ~~phase~~, the stoichiometric ratio of the crystal phase to the glass phase is set in such a way that there is a negligible thermal expansion for a specific temperature range, e.g. 0 to 50°C. The size of the crystallite is a free parameter. The inventors have recognized that for the purpose of achieving a negligible thermal expansion in first approximation it is irrelevant whether many small or a few large crystallites are embedded as long as the volume ratio of crystallite to glass remains constant.

Paragraph starting at page 10, line 15:

The substrate materials in accordance with the invention have crystallite sizes in the magnitude of the wavelength of the incident light, preferably ~~under~~ smaller than half of the wavelength.

At page 10, after line 32, please add the following paragraph:

It should be understood that various alternatives and modifications of the present invention can be devised y those skilled in the art. The present invention is intended to embrace all such alternatives, modifications and variances that fall within the scope of the appended claims.